DOCUMENT RESUME

ED 474 091 IR 021 959

AUTHOR Reigeluth, Charles M.; Lee, Ji-Yeon; Peterson, Bruce; Chavez, Michael

TITLE Formative Research on the Heuristic Task Analysis Process.

PUB DATE 2003-00-00

NOTE 48p.

PUB TYPE Reports - Research (143) -- Tests/Questionnaires (160)

EDRS PRICE EDRS Price MF01/PC02 Plus Postage.

DESCRIPTORS Business; Decision Making; Education; Evaluation Methods; *Formative Evaluation; Group Counseling; *Heuristics; Problem Solving; *Task Analysis; Tutoring

ABSTRACT

Corporate and educational settings increasingly require decision making, problem solving and other complex cognitive skills to handle ill-structured, or heuristic, tasks, but the growing need for heuristic task expertise has outpaced the refinement of task analysis methods for heuristic expertise. The Heuristic Task Analysis (HTA) Method was applied to three settings to generate improvements and more detailed guidance, and to identify variations in the method for different situations. The three settings were group counseling, tutoring on writing skills, and selecting artwork for a product line. The formative research methodology was used to test the method and generate improvements. The three studies produced some common and some unique findings and recommendations. A tentative revision to the HTA method is proposed. Includes seven tables. Interview questions and the HTA Method interview sheet are appended. (Contains 41 references.) (Author)

Formative Research on the Heuristic Task Analysis Process

Charles M. Reigeluth

Ji-Yeon Lee

Bruce Peterson

Michael Chavez

Indiana University

Abstract

Corporate and educational settings increasingly require decision-making, problem-solving and other complex cognitive skills to handle ill-structured, or heuristic, tasks, but the growing need for heuristic task expertise has outpaced the refinement of task analysis methods for heuristic expertise. The Heuristic Task Analysis Method was applied to three settings to generate improvements and more detailed guidance, and to identify variations in the method for different situations. The three settings were group counseling, tutoring on writing skills, and selecting artwork for a product line. The formative research methodology was used to test the method and generate improvements. The three studies produced some common and some unique findings and recommendations. A tentative revision to the HTA method is proposed.

INTRODUCTION

As our society in general and the workplace in particular become more complex, we are finding that a greater number of the activities that people undertake are relatively more heuristic in nature than ever before. Whether in K-12 education, higher education, corporate training, or any other context, to help people learn the heuristic elements of an expert's know-how, we must be able to identify those heuristics.

In analyzing heuristics, we find it helpful to think in terms of two major kinds of expertise—domain and task expertise.

> *Task expertise* relates to the learner becoming an expert in a specific task, such as managing a project, selling a product, or writing an annual plan. *Domain expertise* relates to the learner becoming an expert in a body of subject matter not tied to any specific task, such as economics, electronics, or physics (but often relevant to many tasks). (Reigeluth, 1999, p. 435).

Both procedural and declarative knowledge are important elements of both kinds of expertise. In this research, we focus on task expertise.

For task expertise, we find it helpful to think in terms of two major kinds of tasks: procedural and heuristic. *Procedural tasks* are "tasks for which experts use a set of steps, mental and/or physical, to decide what to do when, such as a high school course on mathematics or a corporate training program on installing a piece of equipment for a customer. *Heuristic tasks* are "tasks for which experts use causal models—interrelated sets of principles and/or guidelines—to decide what to do when, such as a high school course on thinking skills or a or a corporate training program on management skills." (Reigeluth, 1999, p. 435).

The distinction between procedural and heuristic tasks is similar to the distinction between well structured and ill structured domains (Fredericksen, 1984; Resnick, 1988; Simon, 1973). In reality most tasks are neither purely procedural nor purely heuristic, but some combination of the two. We have relatively powerful methodologies for analyzing the expertise that underlies procedural tasks (i.e. the mental and physical steps upon which an expert relies). But we do not have good methodologies for analyzing the expertise that underlies heuristic tasks. This situation is exacerbated by the reality that heuristic knowledge is frequently tacit rather than explicit—that is, experts are often unaware of the heuristics that guide their performance. Therefore, there is a strong need to develop task analysis methodologies for identifying the knowledge that underlies heuristic tasks. This paper briefly reviews literature related to heuristic task analysis. Then it describes three research studies that have been conducted to improve one of those methodologies.

REVIEW OF THE LITERATURE

In reviewing the literature, we identified knowledge elicitation, analysis, and representation as three important aspects of heuristic task analysis. In the following section, we will examine various techniques that are frequently used in this field, from traditional task analyses to heuristic task analysis, on the basis of guidance provided for those three aspects. We found that many of them deal with procedural tasks rather than heuristic tasks, and those that deal with heuristic tasks focus primarily on how to elicit experts' knowledge. Furthermore, it is difficult to find any research that provides guidelines on how to analyze and represent such knowledge.

Knowledge Elicitation

Knowledge elicitation refers to the extraction of domain-relevant knowledge directly from a human expert using various techniques (Jones, Miles, & Read, 1996). Research on knowledge elicitation has been conducted mostly in relation to expert systems that use expert knowledge to perform complex problem-solving and decision-making processes, and many studies reported that knowledge acquisition has continued to be the major bottleneck in the process of building knowledge-based systems (Cooke, 1994; Wood & Ford, 1993).

Based on the belief that the better the data gathered in elicitation, the better the resulting model of expert knowledge, many researchers have been interested in identifying relevant knowledge elicitation techniques. Some of them have focused on the type of knowledge elicited by the technique with an assumption that different elicitation methods tap different types of knowledge (Kitto & Boose, 1987; Kitto & Boose, 1989; Wielinga, Schreiber, & Breuker, 1992). Others have categorized techniques according to the stage in the elicitation process in which the techniques are employed (Olson & Biolsi, 1991; Shaw & Woodward, 1989). There are also research works that organize the knowledge elicitation techniques based on the mechanics of the techniques themselves (Jones et al., 1996; Tomlinson & Johnson, 1994).

One of the most comprehensive reviews of knowledge elicitation techniques was done by Cooke (1994). She categorized various knowledge elicitation methods into three families on the basis of methodological similarity: observations and interviews, process tracing, and conceptual techniques. Table 1 summarizes key characteristics, advantages, and disadvantages of each family of methods based on previous studies.

Insert Table 1 about here

Observations and interviews. This family involves rather direct methods of watching experts and/or talking with them, and is excellent for forming an initial

conceptualization of the problem domain. These are the most frequently used techniques, but they are relatively informal, with much of the specification of methods and analyses left to the elicitor's intuition (Bell & Hardiman, 1989; Brenner, Brown, & Canter, 1985; Cooke, 1994; Cordingley, 1989; Forsythe & Buchanan, 1989). Observation can be used to identify problem-solving strategies that are not consciously accessible to an expert and to verify an expert's description of what he or she actually does without interfering with the expert's task performance and environment. However, it is often difficult to interpret the observation data, especially for heuristic (or complex cognitive) tasks, and there may be some influence of the analyst's presence on the expert's task performance. Besides that, for tasks in which real-time process cannot be controlled, detailed observation is problematic and often impossible (Clarke, 1987). Interviews are usually retrospective in that the expert is required to retrieve information based on past experiences. There are two types of interviews: unstructured and structured. The former is a free-form interview in which neither the content nor the sequencing of the interview topic is predetermined (Cooke, 1994; Hoffman, 1987; Kidd & Cooper, 1985; Weiss & Kulikowski, 1984; Welbank, 1990).

Process Tracing. The second family of techniques, process tracing, includes protocol analysis, content analysis, discourse analysis, and decision analysis. These techniques are performed concurrently with the expert's task performance, record pre-specified types of data (e.g. verbal reports, eye movements, actions), and use those data to make inferences about the cognitive processes underlying task performance (Cooke, 1994). Decision analysis is somewhat different from the rest of this family in that it uses formal statistical methods to provide quantitative information about decisions made by the experts during the task performance.

Conceptual techniques. This family of techniques entails the extraction of domain concepts and the structure or interrelations among concepts. Repertory grid, concept listing, rating, and ranking belong to this family, and they tend to be indirect and require less introspection and verbalization than interviews or other types of verbal report techniques (Cooke, 1994).

Each family of techniques has its own advantages and disadvantages, and there seems to be no one single family that is suited for every purpose. Indeed, the studies on various knowledge elicitation techniques have emphasized the notion that one should not rely on any single method (Cooke, 1994; Hoffman, 1987; Shadbolt & Burton, 1989). It seems that the major problem with knowledge elicitation techniques is not a shortage of methods but a lack of advice on how to select and apply those methods depending on the type of task and contextual constraints. In other words, there has been the general tendency to "name methods without providing much information on how to apply them" (Forsythe & Buchanan, 1989) and "an amazing lack of evaluative information on the methods, particularly in the form of empirical data" (Cooke, 1994).

Knowledge Analysis

Once relevant data are extracted, the next step is to interpret the data. Recent studies have often used computer programs to automate the analysis process, representing a shift away from knowledge analysis in which human analysts are involved toward more 'non-human' based approaches (Olson, Mechitov, & Moshkovich, 1995; Sommer, Morik, Andre, & Uszynski, 1994). For example, Benbenishty (1992) reported the use of a computer program for structured interviews in which the program constantly analyzed the expert's responses, finding inadequately covered areas, identifying apparent contradictions that should be clarified, and eliciting needed refinements (thus overlapping with the knowledge elicitation phase described earlier). He also described how sophisticated programs could be used in protocol analysis, partitioning transcribed protocols of the expert into segments on the basis of speech pauses.

However, there is little guidance concerning the analysis of the data generated by interviews and observations, and without a systematic framework for analyzing such data, the reliability and validity of data gathered from these knowledge elicitation techniques have often been questioned by researchers (Cooke, 1994; Hoffman, Crandall, & Shadbolt, 1998).

Knowledge Representation

As mentioned earlier, knowledge elicitation methods have been mostly used with a fairly narrow set of applications in mind, primarily the development of expert systems and artificial intelligence (AI) systems. Expert systems are computer systems designed to tackle problems normally thought to require the intervention of human experts, and the overall goal of knowledge elicitation is to externalize knowledge in a form that can be implemented in such systems (Cooke, 1994; Hoffman et al., 1998; LaFrance, 1992). Not surprisingly, a central problem for researchers has been to find ways to represent expert knowledge in a manner that computers can use. Some of the frequently used knowledge representation schemes include semantic networks, augmented transition networks, bites, frames, scripts, and grammar. They have been selectively used to construct systems that hierarchically organize information for tutoring, simulation, and parsing of natural language, depending on the type of problem being addressed (Nelson, 1989; Wenger, 1987).

Other types of knowledge representation that are not directly related to computer systems are mostly from traditional task analysis methods such as functional flow analysis, information flow analysis, and interaction analysis. Task analyses have been commonly used in human factors and industrial engineering applications, and have provided a means of representing a task using information that has been elicited through informal observations and interviews. **Functional flow analysis** involves the creation of diagrams that display the primary system

functions and subfunctions in a sequence, and **information flow analysis** displays necessary information and decisions to carry out the system functions in a flowchart. In **interaction analysis**, major constraints that are imposed on the system are identified and presented in a graphical format (Cooke, 1994; Jonassen, Hannum, & Tessmer, 1989; McGraw & Harbison-Briggs, 1989).

It appears that different types of knowledge require different types of representation (Nelson, 1989; Wenger, 1987). A method that can best represent procedural knowledge might not be equally effective for heuristic knowledge, but there is a gap in previous studies in advising how to represent heuristic knowledge.

Knowledge representation is often determined by the purpose of its application. Building an expert system has been a prevalent reason for conducting task analyses, and research on knowledge representation has been driven by that purpose. As a consequence, there is a lack of research on knowledge representations to inform instructional designers on how to utilize heuristic knowledge in developing an instructional system.

In the following section, we will introduce task analysis methodologies that are more focused on heuristic tasks.

Heuristic Task Analysis Methodologies

Olson and Biolsi (1991) present, compare, and contrast a variety of methods for capturing and representing expert knowledge. They summarize the various methods they present as passing through "four distinct stages":

1. elicit behavior from the subject;
2. summarize the behaviors that can be analyzed from different algorithmic perspectives,
3. analyze the data using one of a variety of methods;
4. display the results. (Olson & Biolsi, 1991).

For example, elicitation methods (step 1 above) include interviews, think aloud, grouping items, sorting items and others. Summary methods (step 2 above) include transcribing and using proximity matrices.

Cognitive Task Analysis (CTA)

Cognitive task analysis is a process of identifying the performance components, knowledge structures, and metacognitive knowledge underlying a task (Dehoney, 1995). To elicit expert knowledge, researchers tried various techniques that were first used by cognitive scientists studying human cognition in a lab setting, such as interview, focused discussion, protocol analysis, and simulations, as well as on-site observation (Dehoney, 1995; Black, Dimaraki, Esselstyn, & Flanagan,

1995). Typically CTA involves either participants working on domain-free problems or knowledge workers who solve difficult problems for a living (e.g., aviators or X-ray technicians).

Dehoney (1995) suggested two phases in conducting CTA: (1) to define competent performance of the task, and (2) to derive a performance model that specifies how practitioners actually perform the task. The goal of the first phase is to identify what people must be able to do to accomplish the task at a satisfactory level, what kinds of problems they must solve, what must they know and how must they use this knowledge to solve problems. Based on the analysis of the competency model, the second phase of analysis intends to create a performance model to improve people's performance. However, whether or not an expert's domain-specific skills and knowledge captured in one model can be transferred to other domains remains a controversial issue among researchers in evaluating the effectiveness of such performance models.

Integrated Task Analysis Model (ITAM)

Ryder and Redding (1993) have proposed a task analysis model to combine cognitive task analysis with traditional behavioral task analysis models. They argue that each type of method is incomplete and that they should be used together to adequately represent many tasks.

Ryder and Redding (1993) divide expertise into skills (procedural knowledge), knowledge (declarative knowledge), and mental models. They define mental models as "functional abstractions about a job or job task which provide a deductive framework for problem solving" (p. 85). Thus, mental models may include a variety of conceptual, procedural, decision-making, heuristic and strategic knowledge. Ryder and Redding describe four analysis techniques from the literature that they recommend for developing the mental models: psychological scaling, protocol analysis, cognitive interviewing, and cognitive modeling.

Psychological scaling (Ryder & Redding, 1993) involves statistical techniques to determine the organization of conceptual knowledge and is sometimes used to examine expert skill that is automatic and unavailable for conscious introspection. Protocol analysis (Ryder & Redding, 1993) has experts think aloud while performing a task and is useful for developing heuristic knowledge and mental models. Cognitive interviewing uses structured or semi-structured questions "based a cognitive theory of expertise and a desired framework for representing or using the results" (Ryder & Redding, 1993, p. 79). This method is also useful for developing heuristic knowledge and mental models. Cognitive modeling is a process in which the analyst constructs a model of "the cognitive processes that accurately describe or predict human performance" (Ryder & Redding, 1993, p. 80). Cognitive modeling is a time-consuming process that is applied to complex cognitive domains.

Expertise Analysis

Martin Backler describes a procedure for conducting an expertise analysis that was presented at the 1990 NSPI Conference in Toronto, Canada. Expertise Analysis is a method for using cognitive science tools to uncover how experts solve problems (Backler, 1990). The procedure is as follows:

1. Select a suitable content domain.
2. Identify appropriate experts.
3. Collect suitable problem solving material.
4. Work with your experts.
5. Analyze the problems used.
6. Build a model of how the experts solve problems.
7. Build a model of the knowledge used.
8. Evaluate the model.

Backler gives more specific details about each of the steps listed above, including selecting the proper domain to be analyzed, selecting the most suitable experts to be analyzed, and specifying researchers to use the protocol analysis technique. He also recommends using expert reviews to validate the models that represent the expert's problem solving process and knowledge.

Creating Organizational Knowledge from Tacit Knowledge

Nonaka (1994) describes a systemic process for making tacit knowledge explicit. He breaks tacit knowledge into cognitive and technical elements. The technical element includes specific know-how, crafts and skills. The cognitive element includes working mental models, such as schemata, paradigms, beliefs, and viewpoints. Tacit knowledge is created by individuals and the organization can support individual creativity and provide an environment for individuals to interact with others to create explicit, or organizational, knowledge.

Nonaka proposes that "tacit knowledge may be transformed into explicit knowledge by (1) recognizing contradictions through metaphor, and (2) resolving them through analogy. Explicit knowledge represents a model within which contradictions are resolved and concepts become transferable through consistent and systematic logic" (p. 21). Nonaka asserts that explicit knowledge is created and legitimized through social interaction, which can occur at the level of informal groups, the entire organization, or even between organizations. Nonaka suggests some ways of promoting social interaction to foster explicit knowledge creation.

The Heuristic Task Analysis Method of Elaboration Theory

The Elaboration Theory (Reigeluth, 1999; in press) offers the Heuristic Task Analysis (HTA) method as part of its Simplifying Conditions Method (SCM) for task analysis. This more general method of task analysis is conducted by asking the question, "What is the simplest version of the task that an expert has ever performed?" and "What is the next simplest version?" and so forth. As each version is identified, its place in the learning sequence is simultaneously determined. Therefore, the SCM task analysis method is an integral part of the method for designing an instructional sequence. Furthermore, since most tasks have a combination of procedural and heuristic elements, the procedural and heuristic task analysis methods are integrated into a single process. For these reasons and because this method offers a fair amount of guidance for the task analysis process, we chose this method for our research. Hence, it is described in greater detail next.

The SCM's Heuristic Task Analysis Method

The following are some details on the SCM's heuristic task analysis method. They are an elaboration of the process described by Reigeluth (1999).

Phase I. Prepare for Analysis and Design

1. Prepare. Lay the groundwork for your analysis and design.

1.1 Establish rapport with a task expert.
1.2 Explain the analysis process you will be using.
1.3 Ask the task expert about the nature of the task in general.
1.4 Identify the characteristics of the learners in general.
1.5 Identify the delivery constraints of the task in general.

Phase II. Identify the First Learning Episode

2. Identify the simplest version. Help the task expert to identify the simplest version of the task that is fairly representative of the task as a whole, and to describe the conditions that distinguish that version from all other versions.

- You may want to use some **other criteria** in addition to simple and representative, such as common (how frequently performed the version of the task is) and safe (how much risk there is to the learner and/or the equipment).
- Ask the task expert to recall the **simplest case** she or he has ever seen. The simplest version will be a class of similar cases. Then check to see how representative it is of the task as a whole.
- It may be helpful to start by identifying some of the **major versions** of the task and the **conditions** that distinguish when one version is appropriate versus another.
- Thinking of different conditions helps to identify versions, and thinking of different versions helps to identify conditions. Hence, it is wise to do both simultaneously (or alternately).
- There is no single right version to choose as the "simplest." It is usually a matter of trade-offs. The very simplest version of the task is usually not very representative of the task as a whole. The more representative the simple version can be, the better, for it provides a more useful schema to which learners can relate subsequent versions.
- It may be wise to go through this process with several task experts before going on to Step 3. You may find it necessary to take steps to resolve differences of opinion about which is the best "simplest version" to use.

3. Analyze the organizing content. Analyze the organizing content (mostly heuristics and descriptive theories) for this version of the task.

3.1 Ask the task expert to think of **one specific performance** of the task to analyze, or to videotape a performance for you to review with the expert during the analysis.

3.2 Use a **top-down approach** to analyzing the content (the knowledge upon which the expert's performance is based). In other words, start by identifying the general categories of knowledge that an expert uses, then proceed to analyze each.

- Ask the task expert:
  a) to **describe each decision** that the task expert made,

b) to **identify the kinds of knowledge** that the task expert drew upon to make the decision, and
c) to **describe the specific knowledge** within each kind of knowledge that the task expert used.

- The kinds of knowledge are likely to include:
  - **steps** (procedural knowledge),
  - **guidelines** or **rules of thumb** (heuristic knowledge),
  - **explanatory models** (which explain why the guidelines work),
  - **descriptive models** (which describe the phenomena with which the task expert interacts), and
  - **metacognitive/decision rules** (which the task expert uses to decide which steps, guidelines, and descriptive knowledge, to use when).
- It is generally helpful to start by asking the task expert if there are any **steps** or phases of activities that are always performed for this version of the task. If so, perform a procedural task analysis to identify the sequence of steps and to see if any of those steps can be broken down into substeps, but those substeps must be ones that an expert thinks of and uses routinely in performing that version of the task.
- For guidelines, use the following process (See the example in Table 2 below.):
  1. Identify the ***goals*** for this specific performance of the task under its conditions.
  2. Identify all the important ***considerations*** for attaining each goal. Considerations are the major categories of causal factors that influence performance of the task. If there are a lot of causal factors for a consideration, it is useful to identify subconsiderations for it.
  3. Identify all the important ***causal factors*** for each consideration (or subconsideration).
  4. Analyze each causal factor to identify all ***guidelines*** (prescriptive principles or "rules of thumb") that an expert uses to account for this consideration.

Insert Table 2 about here

- For explanatory **models**, use the following process:
  1. For each guideline, ask the task expert for the reasons why s/he believes it works.
  2. For interrelated guidelines, you are likely to identify a set of related reasons that constitute a causal model or models. Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.
- For descriptive **models**, use the following process:
  1. Ask the task expert what phenomena influenced this particular performance of the task. Try to identify all causal relationships

that characterized those phenomena. Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.

- For metacognitive/**decision rules**, use the following process:
  1. Find out what rules the task expert used to decide when to use which steps, guidelines, and descriptive models during the specific performance of the task being analyzed.
- It is wise **to** query the task expert about any of these kinds of knowledge that are not initially described to you for each decision the task expert made in this specific performance of the task.

3.3 Ask the task expert to think of similar **performances** of the task that constitute a single version of the task. Use each such performance to broaden the steps, guidelines, explanatory models, descriptive models, and metacognitive/decision rules so that they represent the knowledge bases the task expert uses to deal with all performances for that version of the task.

3.4 If time and resources permit, find a second task expert with whom to repeat this entire process (Steps 1 – 3.3) to identify any alternative views of the task and the knowledge that underlies its performance. It may even be wise to repeat this process with several more task experts. And you may want to go back and ask each task expert what s/he thinks about the perspectives of the other task experts, in an effort to reconcile conflicts and select among alternative ways of thinking about and performing the task.

The HTA method has not been rigorously tested and therefore is in need of further research. However, the most important research issue is not the validity of the HTA method, for, like most methods, it is likely to work some times but not always. Rather, given the immaturity of our knowledge about how to analyze heuristic tasks, what is needed most at this point is developmental research—research that is intended to further develop and improve the method. Therefore, our research question is, "In what ways can the HTA method possibly be improved?" To answer this question, it is also necessary to find out what parts of the method are working well and what parts are not working so well. Furthermore, to improve the HTA method, it will likely be important (1) to change parts of the method, (2) to provide more detailed guidance about how to accomplish particular parts of the method, and (3) to identify variations in the method for different situations, such as different kinds of tasks or even different kinds of task experts.

To answer these research questions, we conducted a series of three developmental research studies. These are described next, followed by some general conclusions.

Study 1: The HTA Method Applied to Group Counseling

Methods

The purpose of this study was to improve the HTA method and guidance for use of that method. Thus, the formative research methodology was adopted with emphasis on exploring how the HTA method can be improved when applied to group counseling.

Formative research is a kind of developmental research or action research that is intended to improve design theory (Reigeluth & Frick, 1999). In contrast to research on descriptive theory, which emphasizes validity or how well the description matches the reality of "what is," research on design theory is more concerned with preferability, the extent to which one method is better than other methods for achieving certain goals under certain circumstances. By creating or identifying an instance of a design theory and collecting formative data to improve that instance, one may develop a better understanding of how the theory works in the field and thus be able to propose improvements for the theory, which of course would need to undergo further testing.

Formative research can be used for improving an existing theory or developing a new theory, and in either case, it is a type of case study approach. Case studies can be classified as designed cases or naturalistic cases, depending on whether or not the situation under investigation is manipulated by the researcher or just observed.

This study used a designed case to improve an existing theory, because the HTA process was intentionally instantiated and manipulated by the researcher. It followed the steps suggested by Reigeluth and Frick (1999):

1. *Select a design theory*: The theory under investigation was the HTA method.
2. *Design an instance of the theory*: The design instance in this study was the use of the HTA method to analyze "group counseling," which is a heuristic task.
3. *Collect and analyze formative data on the instance*: To identify problems and improve the HTA method, formative data were collected through interviews with task experts.
4. *Revise the instance*: This application of the HTA method was revised based on the data collected about how to improve it.
5. *Repeat the data collection and revision cycle*: The process of formative data collection and analysis was iterative. This study went through three revision cycles with several rounds of data collection and analysis.
6. *Offer tentative revisions for the theory*: The researcher came up with a set of tentative recommendations to improve the HTA method, based on the improvements made to the instance.

Task

Group counseling was selected as the task to which to apply the HTA method. The nature of group counseling varies depending on the nature of the group that the leader facilitates, and this study focused on the counseling process for "personal growth" groups. The personal growth group is intended to help relatively healthy people to explore personal issues with which most people struggle at various transition periods in life and thus to function better on an interpersonal level (Stockton, Morran, & Nitza, in press).

Group counseling is a combination task with both procedural and heuristic elements. It is procedural in that the activities of the group leader are largely determined by the stages that a group goes through (i.e., forming, norming, storming, and performing), and the leader cannot help the group to progress to the next stage without performing certain tasks (steps) at each stage. However, at a deeper level of analysis, the knowledge required for the leader to decide when and how to intervene is not a set of steps but a set of guidelines and principles, which is heuristic knowledge.

Participants

This study involved three participants as task experts in group counseling (see Table 3). Expert #1 was a professor in the Counseling Department and the most experienced of the three task experts. The other two were doctoral students in the same department. They were all experienced in conducting "personal growth" group counseling, and their expertise ranged from three to more than 20 years.

Insert Table 3 about here

Data Collection Methods

Interview. Semi-structured in-person interviews were used as the primary data collection method. The second author conducted six interviews between September and November 1999. Each interview took 30-90 minutes and was audio taped for analysis.

The purpose of the interviews was to find ways to improve the HTA method for eliciting, analyzing, and representing the expert's heuristic knowledge for performing the task of "personal growth" group counseling. The investigator played two roles, one as a task analyst proficient in the HTA method and the other as researcher searching for ways to improve the HTA method. As task analyst, the investigator developed a set of interview questions (see Appendix A) for the interview based on the HTA method, but as researcher the investigator

was not restricted to the predefined questions. Depending on the expert's response, the researcher revised the HTA method for the next interview. Thus, the overall interview process was flexible and reflective in nature.

The first interview followed the sequence of the HTA method described earlier in this report. It started with asking questions related to the nature of the task in general and then moved into questions related to identifying the simplest version of the task, asking the task expert to recall a specific instance (or case) that fits into the simplest version. For the second interview, several minor modifications were made based on the previous interview, and once the experts agreed on the boundaries of the simplest version of the task, the focus of the interview moved into identifying specific decisions made and the underlying principles and models that the experts used.

Besides changes in the type of questions and the sequence of those questions, each interview used a little bit different technique from the previous ones. For example, after the fourth interview, the researcher (in the role of analyst) provided index cards (Davies, 1997) summarizing the critical incidents as a reference to help the experts recall specific heuristic knowledge already identified, whereas the first three interviews did not have any such reference materials.

Videotapes. Because of the confidential nature of group counseling, direct observation or videotaping of an expert's task performance (as called for by the HTA method) was not allowed. Instead, the researcher (as analyst) used a series of instructional videos that simulated group counseling sessions for beginning group leaders, to provide the analysts with a concrete case[1]. The video series was developed by one of the experts who participated in this study, and it was composed of three videos, each of which covers different stages in group counseling. This study focused on the first three episodes dealing with the beginning stage of group counseling, and it used them as if they were recordings of the experts' task performance[2]. Based on the video, each expert was asked to identify with one of the co-leaders in the video series and explain the decisions of the co-leaders from that person's perspective.

Data Analysis and Interpretation Methods

The HTA method is an iterative process: finishing the first round of HTA is not the end of the study but the beginning of the second round of HTA; and the end of

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[1] The experts could add more details to or delete certain parts, but mostly they accepted the scenario from the video without modification.

[2] This was possible because all three experts who participated in this study were familiar with this video series. Expert #1 was the author of this video series, and the other two experts had taken classes from expert #1 and had studied the videos as class materials.

the second round is, again, the beginning of the third round; and so on. The investigator went through two rounds of HTA in this study.

Triangulation. To enhance the thoroughness of the data, this study involved three experts as data sources. Each of them played somewhat different roles during the interviews. During each round of data collection, expert #2 provided the initial structure of the task setting and knowledge base. Then experts #1 and #3 reviewed the knowledge elements, verified them, and provide additional information. There were a few times when the three experts did not agree with one another. In such cases, expert #1's judgment was accepted, as he was the most experienced group counselor.

Member checks. After each interview with an expert, the researcher transcribed the interview and took the summary and interpretations to the next interview for review. Through this process, the experts corrected errors or misconceptions by the researcher, and the researcher asked additional questions to clarify the information.

Consultation. During the data collection and analysis process, the researcher regularly met with the other three researchers in this study and consulted them in designing the interview protocol and analyzing the data.

Results and Discussion

As mentioned earlier there were two rounds of data collection in this study. The first round involved initial interviews with three experts. Instead of finishing with one expert and then starting with another, the researcher worked with the three experts simultaneously (but separately) due to their time schedules. This situation involved some tradeoffs. It worked well in the sense that the researcher could get the three experts to reach consensus on the simplest version of the task early in the HTA process. However, communicating with all three experts simultaneously was not easy for the researcher, and the researcher had to spend most of the time during the interviews explaining to each expert the previous interviews with other experts. Even though the task was a common one, the experts still had difficulty explaining the detailed decision-making process when the problems to which to apply the process had originally been identified by another expert. Facing this problem, the researcher decided to use an existing instructional video series (with which all three experts were familiar) as a frame of reference, instead of trying to build a new scenario based on each expert's experience.

The second problem the researcher encountered during the first round of HTA was that the researcher lacked expertise in the task of group counseling. The researcher found that, to be able to push the expert to further elaborate his/her automatized (and hence subconscious) task expertise, the analyst needed to speak the same language as the expert and be able to prompt when the expert

had difficulty in finding the right words. Without a certain level of expertise in the task domain, the researcher as task analyst had difficulty doing those jobs smoothly. The researcher tried to become familiar with the field by reading some introductory textbooks and articles written by the primary expert who participated in this study. However, learning about the field was time consuming and could not be satisfactorily achieved within the time constraints.

The third problem was related to the difficulty of categorizing the types of knowledge underlying each decision made by the expert during the task analysis. Even though the researcher explained the differences among the various types of knowledge according to the HTA, such as guidelines and decision rules, often the experts had difficulties in distinguishing those concepts. Not being familiar with the field, the researcher had difficulty labeling the type of knowledge underlying certain decisions. The purpose of identifying the five types of knowledge specified by the HTA was to make sure that the expert did not overlook one of the important types of knowledge, but the benefits of distinguishing among the types seemed to not be worth the extra time required in this case.

The second round of HTA incorporated some new methods to deal with the problems found in the first round. First, the researcher summarized key incidents from the video series on index cards and used them as a reference during the interviews with the experts. This was very helpful in three ways: (1) it helped the experts to recall details about the task performance process; (2) it helped both analyst and experts to see the flow of the task performance process and get back on track when the experts got off-task; and (3) it saved a lot of time in revisiting previous points. One expert commented that the index cards forced him to be more precise during the review and revision process.

Second, the researcher as analyst used a bottom-up approach (identifying knowledge first, then categorizing it as to type) rather than the top-down approach (identifying knowledge within each type) suggested by the HTA method. In the first round, the experts had difficulties in identifying the kind of knowledge underlying each decision and spent a lot of time on that. Thus, in the second round the analyst asked the experts to describe all knowledge related to performing the task first, regardless of the type of knowledge, trying not to interrupt their cognitive process. Later the analyst categorized each piece of knowledge and then asked the experts to verify them. This bottom-up approach seemed to be more efficient than the top-down approach, especially for the less experienced experts.

Based on the findings of this study, the following changes are proposed as possible improvements and described in detail below: (1) incorporate various interview and observation techniques into the HTA process; (2) provide different guidelines for analysts with different levels of task expertise; (3) provide different guidelines for working with task experts with different levels of expertise; and (4)

provide reference material during the interview with task experts. Each of these is described next (see Table 4).

Insert Table 4 about here

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1. Incorporate various interview and observation techniques. In-person interview appeared to be an effective way to elicit the expert's covert heuristics and make them explicit by verbal explanation. However, the expert was not always able to verbalize his or her own thinking process. Thus, the analyst needed to develop his or her own sense of "heuristics" through observing the expert's task performance or reviewing reference materials to fill in the gap between what was said and what remained unsaid. Especially as an analyst with little expertise in the task domain, direct or indirect observations helped the analyst to understand the workflow and task. Unfortunately, for a task that involves interaction with other people or requires confidentiality, such as group counseling in this study, direct observational techniques were not appropriate, and the analyst needed to find alternatives, such as simulated videotapes or staged cases. Given these considerations, specific suggestions for improving the HTA are hypothesized below.

2. Consider the analyst's task expertise level. As Dehoney (1995) suggested, the analyst needs to learn enough about the task to be able to ask the right questions and understand the answers before he or she can further explore the expert's heuristic process. During interviews, the expert sometimes forgot to explain important things or was unable to verbalize them, and having a certain level of domain expertise would have helped the analyst to be aware of any missing knowledge from the expert 's explanations. Besides that, the analyst's early lack of confidence in the task hindered building rapport with the expert throughout the analysis process. Thus, it is recommended that the SCM-HTA provide the following additional guidelines for analysts with limited task expertise:

1. During the preparation, review basic reference materials and try to become familiar with key concepts and jargon in the field.
2. It is likely that the more complicated the version of the task is, the more task knowledge is required for the analyst. Thus, the analyst with limited task expertise should begin by identifying the simplest version of the task, rather than trying to expand the analysis to the next version.

3. Develop strategies for working with multiple experts. Having multiple experts was beneficial, but working with more than one expert required special strategies for the analyst. It is recommended that the analyst start working with the least experienced expert, finish the first round with him or her, and then start the next round with the next least experienced expert. The less experienced experts' knowledge seemed to be less automatized, and thus those experts were

more conscious of their own heuristic knowledge. They tended to provide more information than the more experienced experts. Later, the analyst should ask the more experienced expert to review the results from the previous interviews. The more experienced experts provided more insightful information, which made them better reviewers. Nevertheless, it worked well to have a focus-group interview with multiple experts in the beginning, to reach consensus on the simplest version of task.

4. Provide reference material during the interview. When asked to describe the task performance process relying on his or her memory, each expert tended to be rather abstract in his or her explanations and forget to tell the details. Having some kind of reference material (e.g., index cards summarizing critical incidents during the task performance or video/audio tapes of the task performance) provided contextual information when needed and thus helped the expert to be more precise. During the iterative interview process, the visual aid also helped the expert to keep on track. Especially under circumstances with time constraints, using index cards was a way to save time.

Study 2 - The HTA Method Applied to Tutoring on Writing Skills

Methods

As in Study 1, the purpose of this study was to improve Reigeluth's HTA process by using the formative research methodology. This study followed the steps suggested by Reigeluth and Frick outlined in study 1.

Task

The heuristic task chosen for this study was tutoring university undergraduate students who needed extra assistance with their writing skills. Specifically, the task concerned the decision-making process in which an expert writing tutor engages to determine the direction and focus of the tutoring session.

As Reigeluth (1999) pointed out, tasks can be based on a combination of both procedural and heuristic knowledge. Since the goal of this study was to focus on heuristic elements in this analysis, the task was selected to meet the following criteria:

1. The task must involve higher-level writing concerns such as unity, coherence, and voice.
2. The task must occur during a one-on-one, one-hour-long session where the expert has the full attention of the tutee, rather than as part of a classroom exercise
3. Any procedural elements will primarily occur during the introduction and conclusion phases of the tutoring session.

By its very nature, a tutoring session requires a lot of heuristic expertise, because it is determined more by events that occur during the tutoring event than by any predetermined procedural steps. What occurs during the tutoring session depends on both the writing situation and the tutee. The writing situation includes why the tutee is being tutored, the relationship between the tutee and the teacher, the interest level of the topic being written about, and the number of drafts already written. The tutee includes any previous experiences, both positive and negative, that the tutee brings to the tutoring session.

Participants

Two experts were chosen based on their level of expertise and the approval of their supervisors. The first expert was completing his Masters in English and was in his second year of tutoring. The second expert had tutored during the last two years of her BA in English and was entering an MA program in English. Both experts had extensive experience tutoring all levels of writing students, and both were highly recommended by their writing center supervisors.

Insert Table 5 about here

A third tutor was also recommended and interviewed as a potential participant in this study. However, the recommendation came without the experience and evaluation credentials listed above, so he was not included in this study.

Data Collection Methods

Interview: As in study 1, the main data gathering method was the personal interview, and the researcher both elicited heuristic knowledge (analyst) and conducted formative research (researcher). Two interviews were conducted within one week of the tutoring session that was being analyzed. Because of the tutors' lack of time to spend on this research, each interview was limited to approximately 60 minutes.

The researcher served as an analyst who used the HTA method with the task experts in order to determine the strengths and weaknesses of the HTA method. Both of the interviews were conducted within one week of the tutoring session that was being analyzed. Because of the tutors' lack of time to spend on this research, each interview was limited to approximately 60 minutes. Prior to the interviews, each of the tutors was sent emails describing terms used, definitions, an outline of the interview questions, and a brief explanation, written in their terms, of the purpose, expected results, and use of this research. Before the actual interview, the researcher reminded each tutor of what was sent to them earlier and asked if any terms or points needed to be clarified. At this time, the researcher also pointed out to each expert writing tutor that a) it was unclear whether the task about to be analyzed was actually based on heuristic

knowledge and b) it was unclear whether the questions would be able to access that knowledge. This was done to reduce any anxiety that the writing tutor might experience if she or he could not produce information that the researcher desired.

Because of the experiences of researcher #1 and the recommendations of researcher #3, this study used index cards (for the expert to read and hold) for recording each question, recording the expert's response, making the interview process and results more open and visible (rather than hidden away on the researcher's legal pad), and placing the focus on the cards (knowledge generated) rather than on the researcher. Both of the expert writing tutors referred to the cards during the interview and made changes to their comments as the interview progressed.

Because the writing tutors did not have the time to be repeatedly interviewed as in Study 1, this study did not attempt to identify the simplest version of the task, nor did it verify the task with other expert writing tutors. For the first interview, the writing tutor provided an audiotape of the session to be analyzed, and the analyst, after previewing it, chose one decision point as the focal point for the interview. The researcher's decision to choose the specific area to focus on does not reflect the HTA methods, but was made so that the majority of the 60 minutes allowed by the expert tutor for the interview would be spent on eliciting heuristic knowledge. Other than this change, the first interview followed the HTA method as described earlier in that it asked the tutor to identify goals, considerations, causal factors, guidelines and explanations.

Based on this first interview, the HTA methodology was altered slightly for the second interview so as to assist the tutor to better recall the tutoring situation. The analyst had the tutor respond to specific questions about the actual tutoring experience, the tutee's characteristics, and the tutee's essay prior to having the tutor recall and reflect on her decision-making processes. He then had the tutor identify the decision areas to focus on during the tutoring session. Afterwards, he had the tutor choose the concern that was most available to her. This, then, became the subject of the heuristic task analysis.

Data Analysis and Interpretation Methods

There were no follow-up interviews or member checks as in Study 1 to determine the validity of the tutors' responses due to the writing tutors' lack of time to spend on these tasks. However, because of the researcher's expertise in this area, he informally concluded that the data collected was not spurious.

At the conclusion of each interview, the experts were asked to review and modify what was recorded during the interview. The researcher asked each expert for ways to improve the interview process and to comment on its effectiveness in eliciting the knowledge underlying their decision-making thought process. Both

offered suggestions about ways to help them recall the previous tutoring situation and about the limitation of focusing on only one aspect of the tutoring process. The second expert confirmed what the first had concluded. After each interview, tentative changes were made to the HTA process.

Results and Discussion

As mentioned in Study 1, the formative research methodology is an iterative process whereby formative evaluation of one instance (application of the HTA method) is used to improve the HTA method, which is then used to carry out another instance. Altogether, the researcher created two instances of the HTA method. After each instantiation, the researcher collected strengths and weaknesses with the HTA method as applied to writing tutors and implemented refinements to be used during the next instantiation.

In the interview after the first instantiation of the HTA method, the first tutor mentioned how the process helped him think about his own tutoring strategies. He also mentioned that having to recall from memory a tutoring session that was done even within the last seven days was not easy. The tutor suggested the following refinements to the HTA method. 1) The top-down process seemed effective. 2) Because the tutor experienced some difficulty recalling the specific tutoring session, the analyst (researcher) asked some specific questions about the tutee, the paper, and the tutee's reactions to the tutor's suggestions. Both tutors said this helped them get into the flow of the previous tutoring session, and the researcher observed a marked increase in awareness and confidence after assisting the tutor's recall. 3) 5x8 cards were effective in that the tutor referred back to them to align his insights into the tutoring process with previous statements. 4) The tutor, when identifying the guidelines, focused more on how to hold an effective tutoring session than on what influenced his decision to focus on a specific tutoring objective. In addition, 5) the researcher suspected that the results of the HTA might have been richer if the task expert (tutor) had been given more control over the decision point selection process.

Considering these findings, changes were made to the HTA method, which was then used to carry out the second instantiation. In the post-analysis interview, the second task expert mentioned that, after discussing the context of the tutoring session, she had a clear picture of what was going to be analyzed. The researcher also noted the relative ease with which this expert could talk about the decision point as compared to the previous writing tutor. The researcher believes that helping the expert recall the task, the context of the tutoring session, the tutee, and the tutoring session caused the increased ability to discuss the area. Therefore, the findings from the second instantiation include the following. 1) Helping the tutor to access a recent tutoring session created a rich context to draw from. 2) Helping the tutor access the context of the tutoring situation, though, did *not* prevent the tutor from referring to the general goals when listing guidelines rather than the specific decision point of the task. 3)

Having the tutor list and choose the decisions she made during the tutoring session was time consuming but resulted in richer heuristics.

In summary, an important concern involves the task expert's tendency, when explicating the guidelines, to focus on the goals and not on the decision points for attaining the goals. During both instantiations, the writing tutors gave the guidelines they used for deciding on the goals of the tutoring situation rather than giving guidelines for deciding how to attain a goal during the tutoring session. When this occurred, the researcher gently prodded the experts to focus on the decision points rather than the goals. However, when the experts could not provide that information, the researcher decided to review previous sections and then ask that question again. After the experts referred to the goals again, the researcher decided not to push the expert any further, seeing that they both were unable to provide that information.

Another concern involves the first expert's difficulty in recalling the tutoring session despite the fact that the session occurred only one week prior to the interview. Measures taken to assist the second expert's ability to recall the tutoring session showed a dramatic improvement. Table 6 presents a chart outlining what worked and what needed improvement for this instantiation of the HTA method as applied to tutoring.

Insert Table 6 about here

Study 3 - Selecting Artwork for a Commercial Product Line

Methods

The third study tested the HTA method in a corporate setting. As in the previous two studies, formative research was the methodology, using a designed case to generate possible improvements in the HTA method.

Corporate executives want a "big bang for their buck," and analysis is often looked upon as a time-consuming activity with questionable impact. The aim of this study was to develop a rapid, high-impact version of the HTA method for corporate settings. Thus, the study was designed to provide insight into the following research questions:

1. How can the speed and effectiveness of the HTA method be improved for eliciting, analyzing, and representing heuristic knowledge from experts in corporate settings?
2. What guidance could be added to the method to assist analysts in corporate settings?

The time constraints for this study dictated that the research be limited to a single interview cycle with one task expert, lasting no more than a total of three to four hours.

Task

The heuristic task chosen for this study was deciding whether a submission of artwork was suitable for one of the company's product lines. This is a judgmental decision-making task requiring a fair amount of experience and know-how. The task expert verified that the task was important to the company, that she was considered to be an expert at the task, and that it was not easy to articulate the expertise required to perform the task. The heuristic nature of this task was verified by an expert in the HTA method, Charles Reigeluth.

Participant

The task expert was recruited by calling a local business that had collaborated with the Instructional Systems Technology Department at Indiana University in the past. A manager in the design department enthusiastically agreed to participate in the study. The expert and the analyst discussed possible complex decision-making tasks over the telephone and came to an agreement on an appropriate task.

Data Collection, Analysis, and Interpretation Methods

Interview: The researcher/analyst conducted two audio taped, one-and-a-half-hour interviews with the participant (task expert) in a conference room at the expert's place of business. The analyst/researcher referred to an interview sheet (described below) to ensure that he was adhering to the guidelines of the HTA method, although he also allowed the interview to be somewhat unstructured as seemed appropriate to gather the heuristic knowledge and data for improving the HTA process. After one-and-a-half hours he reached a saturation point in terms of gathering the essence of the task and the key heuristics and concluded he could not effectively continue the analysis without first going back to his office and organizing the information collected. The expert agreed to continue the interview the following week.

The analyst/researcher logged "significant chunks" of the audio tape on 3" x 5" cards. His criterion for "significant chunks" was any piece of knowledge that fit into one or more of the types of knowledge listed in the HTA method. He examined these knowledge elements to determine what missing ones he needed to ask about in the follow-up interview. Then in the role of researcher, he re-examined the interview results for deviations from the HTA method to see where the method was effective in eliciting heuristic expertise and where deviations were helpful. He discussed his preliminary findings with Reigeluth and worked with him to plan the second interview.

The analyst/researcher conducted a second, audio taped, hour-and-a-half-long interview to fill in gaps in the analysis and verify with the expert that the heuristics corresponded to the expert's understanding of the task. After the second interview, the analyst/researcher again analyzed the audio tape to fill in gaps in the heuristic knowledge generated. Then in the role of researcher he analyzed the interview process as recorded in the audio tapes to determine how the process deviated from the HTA guidelines and to develop recommendations for possible improvements in the HTA method.

In an attempt to ensure that the interview conformed to the HTA method as much as possible, an interview sheet was developed and used (see Appendix B). The steps on the interview sheet were written as questions to be asked using terminology that seemed understandable to a layperson. The rationale for this was that one of the goals of the study was to test the HTA method in a business context that placed a premium on short cycle time (e.g., short interviews). Using lay terminology was hypothesized to decrease the net amount of time for analysis by eliminating time for explaining academic terms. The interview sheet was edited by Reigeluth to verify that it accurately represented the HTA method in its current form.

It is important to note that the HTA method is a set of guidelines to be used heuristically, not as a step-by-step checklist of questions to ask. One limitation of this study was this researcher's limited experience as an "HTA analyst," who would ideally have the guidelines in mind and would have the know-how to choose the appropriate guidelines most of the time and to adeptly recover from inappropriate choices the rest of the time.

Results and Discussion

The research questions for this study addressed the speed and effectiveness of the HTA method for analysts in corporate settings.

Speed of the HTA method. The task expert originally agreed to three hours of interview time, and the analyst/researcher complied with this limit. Afterwards the expert said the amount of time spent was within acceptable limits. The analyst/researcher also spent about six hours analyzing the interview audio tapes to synthesize the expert's task knowledge.

Approximately half of the interview time was spent eliciting and categorizing the expert's heuristic task knowledge, while the rest of the time was spent developing rapport, explaining the process, selecting and describing the task, and discussing associated tasks. Analysis of the discussions on associated tasks revealed that at some points these discussions helped the analyst/researcher better understand the context of the main task, while at other points these discussions were cases of getting sidetracked from the purpose of the analysis.

The time spent on formative research on the HTA method is not included in the above six hours of analysis, as this has no bearing on the amount of time spent analyzing the heuristic task knowledge.

The analyst/researcher found a number of areas in which the speed of the HTA method might be enhanced. Two are discussed in this section. The others are the result of improving the effectiveness of the method and are discussed in the next section. The analyst/researcher noticed that almost an hour was spent identifying the simplest version of the task and distinguishing it from other possible versions. This can be important for training purposes, as outlined in the SCM methodology. However, in a business context, there can be other purposes for conducting the heuristic task analysis. The results of a heuristic task analysis can be used to generate job aids for experts, to help designers structure knowledge-management systems, and for other purposes. If training is not the primary purpose, then the analyst might choose to spend less time identifying the simplest version and other versions (Step 2. Identify the first learning episode). Such information might still be useful for distinguishing experts and novices, even though sequencing course material is not of concern. In this study, the analyst/researcher concluded that this step could have been concluded with significantly less time (approximately 20 minutes less), without diminishing the quality of the results.

Recommendation: Unless using the HTA method specifically for training purposes, perform Step 2, "Identify the simplest version," only if needed to distinguish between experts and novices or as one way of helping the expert access tacit knowledge. As the expert examines various instances of a task in search of heuristics, it may be helpful to distinguish between simpler and more complicated versions.

Analysis of the data showed that almost an hour was spent on tasks closely related to the task studied. Part of this time was spent on placing the main task in the context of other tasks and part on analyzing the related tasks. When the expert explained the nature of the task in general (Step 1.3), it was helpful to have the expert also mention tasks that are closely related. This seemed to speed up the overall process by avoiding confusions and time wastage caused by mixing details of two different tasks at a later point in the interview. Tasks can be related in various ways. They might occur in tandem with, or come right before or after, the chosen task, or they might have a causal relationship with the chosen task. The analyst needs to be aware of these tasks and be alert for digressions.

Recommendation: When performing Step 1.3, have the expert briefly discuss any closely related tasks and clearly distinguish between the main task and the related tasks during the remainder of the task analysis.

Increasing the effectiveness can also increase the speed of the HTA method. This is addressed in the next section.

Effectiveness of the HTA method. The HTA method seemed to be effective in its primary function of eliciting heuristic knowledge from the expert. At one point, the expert apologized for not being able to explain how she knew the artwork was right for their products, but then she proceeded to discern several criteria that were fundamental to making such a decision. The expert was satisfied with the criteria and indicated that they explained how she made the decision on selecting artwork, although she did not consciously use the criteria as such.

The types of knowledge delineated in Section 3.2 of the HTA Method were found to adequately cover the range and types of task knowledge described by the expert. The analyst/researcher did, however, have problems managing the two tasks of classifying the expert's knowledge and directing the interview to dig deeper into the expert's tacit knowledge. More practice with the methodology should alleviate this. The analyst/researcher noticed during the analysis that certain verbs used by the expert were indicators of tacit knowledge. Examples of these verbs are: *know*, *like*, *feel*, *see*, *determine*, *understand*, and *decide*. When the analyst/researcher asked the expert why she liked a certain piece of art, she struggled at first to find reasons, but eventually she isolated specific characteristics that distinguished artwork she liked from pieces that she did not find acceptable.

Recommendation: Step 3.2 should include guidance specifically focusing on the expert's communication. This analyst/researcher recommends adding this guidance: The expert's language will often contain clues that can help the analyst find tacit knowledge. Especially common are words, such as *know*, *like*, *feel*, *see*, *determine*, *understand*, and *decide.* The analyst should probe the expert for explicit details that can be communicated to others by asking, for example, *what* they know, like or feel, *what criteria* they use to determine something, and *how* they decide.

Upon further analysis and reflection the analyst/researcher developed a model for thinking about how to view the knowledge elicitation and representation process, involving three components. The three components are: (1) the expert's internal representation of her or his knowledge—the tacit knowledge, (2) the manner in which the expert expresses the internal representation using language or other means and the manner in which the analyst guides the interview or elicits the tacit knowledge—the expert/analyst dialog,[1] and (3) the manner in which the analyst and the expert decide to represent the knowledge—the explicit knowledge.

This model can be useful to the analyst for eliciting tacit knowledge and for transforming the tacit knowledge into explicit knowledge. For example, two experts might use the same verbs, such as *know* and *like*, to communicate

different tacit knowledge, or they might use different words to communicate what is basically the same tacit knowledge. Furthermore, different people might prefer one explicit representation to another, as we can see with the oft-discussed differences between visual, oral, and kinesthetic learners. This three-component model might be useful in helping the analyst to conduct the HTA process.

The guidance in "Step 3, Analyze the organizing content" appears to focus on how to elicit and how to represent the tacit knowledge. The elicitation guidance appears to reflect a single elicitation style, focusing on a single specific performance at a time. For example, Step 3.1 has the expert focus on one specific performance of the task, whereas the expert in this study sometimes hopped from one instance to another as she attempted to articulate her tacit knowledge. Further research could focus on whether the elicitation guidance provided by the HTA method should be expanded to provide a variety of types of elicitation styles and techniques for varying situations, experts, and analysts.

Recommendation: Guidance in Step 3 should clearly distinguish between guidelines for eliciting and those for representing the tacit knowledge. Furthermore, elicitation guidance should be generalized and expanded. Specifically, under Step 3.1, this analyst/researcher recommends adding the following bullet point: Sometimes task experts find it helpful to compare two or more instances when trying to articulate their tacit knowledge.

The guidance focusing on how to represent the tacit knowledge does not attempt to distinguish between representations of tacit and explicit knowledge. The theory of knowledge used in the HTA method breaks the knowledge into task goals and decisions with several types of knowledge that the expert uses in making decisions and carrying out the task. In the HTA method these types of knowledge are meant to represent the expert's tacit knowledge. The analyst is left to assume that this explicit knowledge framework is a good fit for the tacit knowledge of the expert, but further research on representing expert tacit knowledge may show that the choice of explicit representation depends on the expert's tacit knowledge. Clearly, the ultimate goal of the HTA method is to provide a useful explicit representation of the tacit knowledge.

Recommendation: Additional guidance should be developed on how to represent explicit knowledge. Although this analyst/researcher has only begun to research this point, such guidance could come from fields such as task analysis or the expert's specific field. One area of interesting research would be collaboration between the expert and the analyst to develop an explicit representation for knowledge deemed critical.

Guidelines for analysts. Throughout the two interviews, the analyst/researcher made a conscious effort to avoid academic jargon, and the expert seemed to rapidly understand everything the researcher was saying. In moments where the

analyst/researcher caught himself using a technical term, he laughed it off with the expert and used the moment to increase rapport.

The analyst/researcher wrote down many of the points the expert made on index cards. It was helpful to have these out on the table, and both referred to them a number of times during the two interviews. The cards also helped the analyst/researcher stay on track or get back on track, when sidetracked.

Table 8 presents a summary of the strengths and weakness of the HTA Method in Study 3.

Insert Table 8 about here

CONCLUSIONS AND RECOMMENDATIONS

Similarities and Differences among the Results

The following summary makes it clear that the three studies have some common findings, but that each also has unique findings.

Study 1

- In interviewing several experts simultaneously, it helped to have them all think of the same case during the analysis process. Prior to doing that, differences in heuristic knowledge were confusing. However, based on this experience, it may be better to complete the analysis with one expert, then conduct the analysis with another, and so forth, so that you create a separate analysis for each expert rather than one single analysis. The advantages appear to be that (1) each expert knows what has transpired to date in their analysis and (2) similarities and differences in heuristic knowledge of the experts are catalogued in separate analyses, making subsequent comparisons and discussions easy.
- When working with more than one expert (which is highly recommended), it worked better to start with the least experienced one, finish with him/her, and proceed to progressively more experienced ones, one at a time. However, it appears that it would have been beneficial to have a focus group interview with all the experts in the beginning to reach consensus on the simplest version of the task.
- It would have been better if the analyst had started with at least a basic level of expertise in the heuristic task, so that the analyst could more easily understand the terms and ideas that the experts used and could prompt the experts when they were having difficulty expressing their heuristic knowledge. Such expertise could also improve the analyst's rapport with the experts. Furthermore, it would have been helpful for the analyst to observe the

performance of the chosen case.

- It was helpful to summarize the key incidents from the chosen case on index cards and refer to them during the interviews. The benefits were: (1) it helped the experts to recall details about the task performance process (2) it helped both analyst and experts to see the flow of the task performance process and get back on track when the experts got off-task, and (3) it saved a lot of time in revisiting previous points.
- It worked better to have the experts identify "freeform" whatever knowledge they could about the task and later try to categorize it as to types (steps, guidelines, explanatory models, descriptive models, and metacognitive/decision rules) and fill in any gaps, rather than trying to get the experts to identify knowledge systematically within each type of knowledge.
- Categorizing the expert's knowledge as steps, guidelines, explanatory models, descriptive models, and metacognitive/decision rules was difficult, and its benefits may not have outweighed its costs. The benefits need to be clarified for the analyst.

Study 2

- Identifying knowledge within categories seemed to work well. (Note that this contradicts a finding from Study 1.)
- It was beneficial to help the expert reconstruct and articulate a specific case for which she performed the desired version of the task and within which her decisions (and goals) were formulated.
- It was beneficial to periodically ask the expert some questions about the chosen case, to keep the analysis focused on the flow of that version of the task.
- It was useful to help the expert think about ways the specific case fell short of how it should have been done (an ideal case for this version of the task) and to have the expert offer guidelines for how this specific case should have been done.
- It helped to summarize on index cards the key incidents from the chosen case and refer to them during the interviews, to help the expert align her insights into the task with previous statements.
- It was helpful for the analyst to have the expert explain the goals in task-specific terms rather than in abstract terms.

Study 3

- When performing Step 1.3, it was helpful to have the expert briefly discuss closely related tasks and clearly distinguish between the main task and the related tasks during the remainder of the analysis.
- Because training was not a primary purpose of the task analysis, performing Step 2 seemed most helpful in distinguishing between experts and novices and assisting the expert in articulating the tacit knowledge. More time would be spent on this step if the analysis were being done for training purposes.

- It would have been helpful to have guidance in Step 3.2 about using particular words (such as know, feel, like, see, understand, determine, and decide) as the focus for probing the expert's tacit knowledge.
- Additional guidance on elicitation strategies might be helpful. One elicitation strategy might focus on types of instances, for example, comparing similar, different, or easy and difficult instances. Another elicitation strategy might focus on how the task expert approaches the instances, for example, comparing, contrasting, narrating, or thinking of metaphors for instances.

Suggestions for Improving the HTA Process

The following is a tentative revision of the HTA process based on the findings of these three formative research studies. The changes and additions are in *italics*.

Phase I. Prepare for Analysis and Design

1. *Decide on a task to analyze and be clear about the reasons for analyzing it.*
2. *Make sure you have enough task knowledge to have a good command of terminology and key ideas.*
   - *If you don't have enough task knowledge, review basic reference materials and try to become familiar with key concepts and jargon in the field.*
   - *If you have limited task knowledge, it would be better to begin by identifying the simplest version of the task, rather than trying to expand the analysis to the next version.*
3. *Make sure you have enough knowledge about the uses of the task description.*
   - *If the task description will be used primarily for deciding on the content and sequence of instruction, identify the characteristics of the learners in general and identify the delivery constraints of the instruction in general.*
4. *Arrange to interview multiple experts.*
   - *Identify at least 2 or 3 experts to interview.*
   - *Plan to complete the analysis with one expert before initiating the analysis with another.*
   - *Plan to interview the least experienced expert first and proceed to interview progressively more experienced experts in order. The less experienced experts are likely to have less automatized knowledge, and thus be more conscious of their own heuristic knowledge. They tend to provide more information than the more experienced experts. On the other hand, the more experienced experts can provide more insightful information, which makes them better reviewers.*
   - *Ask one or more of the task experts to record their performance of a very simple version of the task, and review the recorded material in advance of the analysis; or observe the task expert's task performance (more than once if possible).*
5. *Prepare in conjunction with the first (next) task expert.*
   - *Establish* rapport with the task expert.
   - *Introduce* the HTA method to the expert.
   - *Explain basic terms (i.e. guidelines, explanatory models, etc.).*
6. *Prepare for the interview.*
   - *Prepare interview materials (i.e., index cards to summarize critical incidents during task performance).*
   - *Practice the HTA interview process if you are not very experienced in it.*

- *Arrange the interview logistics (e.g., reserve a conference room where you can work without interruptions).*

Phase II. Identify the First Learning Episode

7. *Identify* the simplest version. *Hold a focus group interview with multiple task experts, and help them to reach consensus on* the simplest version of the task that is fairly representative of the task as a whole. Also help them to describe the conditions that distinguish that version from all other versions.
   - You *may* want to use some other criteria in addition to simple and representative, such as common (how frequently performed the version of the task is) and safe (how much risk there is to the learner and/or the equipment).
   - It may *be* helpful to have the expert briefly discuss closely related tasks and clearly distinguish between the main task and the related tasks during the remainder of the analysis
   - Ask the task experts to recall the simplest case they have ever seen. The simplest version will be a class of similar cases. Then check to see how representative it is of the task as a whole.
   - It may be helpful to start by identifying some of the major versions of the task and the conditions that distinguish when one version is appropriate versus another.
   - Thinking of different conditions helps to identify versions, and thinking of different versions helps to identify conditions. Hence, it is wise to do both simultaneously (or alternately).
   - There is no single right version to choose as the "simplest." It is usually a matter of trade-offs. The very simplest version of the task is usually not very representative of the task as a whole. The more representative the simple version can be, the better, for it provides a more useful schema to which learners can relate subsequent versions.
   - *It is wise to go through this process with several task experts together and reach consensus before going on to Step 8.* You may find it necessary to take steps to resolve differences of opinion about which is the best "simplest version" to use.
8. Analyze the organizing content. *With the least experienced expert you have not yet interviewed,* analyze the organizing content (mostly heuristics and descriptive theories) for this version of the task.
   - 8.1 Review the recorded material (or any other visual aid) with the task expert.
   - 8.2 Ask the task expert to think of and describe one specific performance of the selected version of the task to focus on for your analysis, or ask if a videotaped performance would be a good case for you to focus on with the expert during the analysis.
     - *It is often helpful to have a videotape of a typical performance of the simplest version of the task, so you and the task expert can review it during the analysis process, but asking the task expert to recall one specific performance and keep it in mind throughout the process is a more convenient and inexpensive, albeit often less effective, alternative.*
     - *If you don't have a videotape, It may be helpful to have the expert describe contextual information and particulars of the specific performance, describing how the expert began the case, how it progressed (in sequence), how participants reacted, and how the expert dealt with any problems that arose.*
     - *It may be helpful to prioritize the problems/concerns that arose and*

the decisions/actions that the expert used to deal with them.

8.3 *Decide whether to use a top-down or bottom-up approach to analyzing the content (the knowledge upon which the expert's performance is based). If top-down, use Step 8.4 and skip Step 8.5. If bottom-up, skip Step 8.4 and use Step 8.5.*

8.4 *If top-down approach,* start by identifying the general categories of knowledge that an expert uses, then proceed to analyze each.

- *Ask* the task expert:
  a) to describe each decision that the task expert made,
  b) to identify the kinds of knowledge that the task expert drew upon to make the decision, and
  c) to describe the specific knowledge within each kind of knowledge that the task expert used.
- The kinds of knowledge are likely to include:
  - steps (procedural knowledge),
  - guidelines or rules of thumb (heuristic knowledge),
  - explanatory models (which explain why the guidelines work),
  - descriptive models (which describe the phenomena with which the task expert interacts), and
  - metacognitive/decision rules (which the task expert uses to decide which steps, guidelines, and descriptive knowledge, to use when).
- It is generally helpful to start by asking the task expert if there are any **steps** or phases of activities that are always performed for this version of the task. If so, perform a procedural task analysis to identify the sequence of steps and to see if any of those steps can be broken down into substeps, but those substeps must be ones that an expert thinks of and uses routinely in performing that version of the task.
- For **guidelines**, use the following process (See the example in Figure 1 below.):
  1. Identify the **goals** for this specific performance of the task under its conditions. *It may help to have the expert explain the goals in task-specific terms rather than in abstract terms and to think of the goals as ideal outcomes.*
  2. Identify all the important **considerations** for attaining each goal. Considerations are the major categories of causal factors that influence performance of the task. If there are a lot of causal factors for a consideration, it is useful to identify subconsiderations for it.
  3. Identify all the important **causal factors** *that relate to* each consideration (or subconsideration).
  4. Analyze each causal factor to identify all **guidelines** (prescriptive principles or "rules of thumb") that an expert uses to account for this consideration.

Insert Figure _ about here

- For **explanatory models**, use the following guidelines:
  - For each guideline, ask the task expert for the reasons why s/he believes it works.
  - For interrelated guidelines, you are likely to identify a set of related reasons that constitute a causal model or models. Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.
- For **descriptive models**, use the following guideline:
  - Ask the task expert what phenomena influenced this particular performance of the task. Try to identify all causal relationships that characterized those phenomena.
  - Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.
- For **metacognitive/decision rules**, use the following guideline:
  - Find out what rules the task expert used to decide when to use which steps, guidelines, and descriptive models during the specific performance of the task being analyzed.

- It **is** wise to query the task expert about any of these kinds of knowledge that are not initially described to you for each decision the task expert made in this specific performance of the task.
- *If* **the** *expert uses words such as know, feel, see, understand, like, determine, and decide, that may be an indication that heuristic knowledge underlies that particular performance.*
- *It is* **often** *helpful to periodically ask the expert some questions about the chosen case, to keep the analysis focused on the flow of that version of the task.*
- *It is useful to help the expert think about ways the specific case fell short of how it should have been done (an ideal case for this version of the task) and to have the expert offer guidelines for how this specific case should have been done.*
- *It is wise to have some kind of reference material (e.g., index cards summarizing critical incidents of the task or videotapes of the task) to provide contextual information and cues and to help the expert be more precise. During the iterative interview process, the visual aid also helps the expert keep on track. Especially under circumstances with time constraints, using index cards is one of the ways to save time.*
- *It may be helpful to use index cards for all of these kinds of knowledge, filling them out with the task expert during the analysis process with one piece of knowledge per card, and arrange the cards in some order on a table in front of both of you, so you can easily switch from one part or aspect of the task to another.*

8.5 *If bottom-up approach, ask the expert to describe each decision that s/he made and the process through which s/he went to make each decision.*

- *After the interview, try to categorize each piece of heuristic knowledge according to these categories:*

- steps (procedural knowledge),
- guidelines or rules of thumb (heuristic knowledge),
- explanatory models (which explain why the guidelines work),
- descriptive models (which describe the phenomena with which the task expert interacts), and
- metacognitive/decision rules (which the task expert uses to decide which steps, guidelines, and descriptive knowledge, to use when).

- *Be sure to "member check" the interview results with the expert in a later interview to verify/identify the types of knowledge underlying each decision.*

8.6 Ask the task expert to think of similar performances of the task that *are within the realm of the* version of the task *you are currently analyzing.* Use each such performance to broaden the steps, guidelines, explanatory models, descriptive models, and metacognitive/decision rules so that they represent the knowledge bases the task expert uses to deal with all performances for that version of the task.

8.7 Repeat this entire process (Steps 5 - 8.6) *with the next least experienced task expert* to identify any alternative views of the task and the knowledge that underlies its performance.

- *For each more experienced expert, you should summarize the previous description of the task and ask the expert to review it, in an effort to reconcile conflicts and select among alternative ways of thinking about and performing the task. The more experienced experts can provide more insightful information, which makes them better reviewers.*

Formative research data indicate that this revised HTA process would have been more effective for the three cases investigated here. It remains to be seen whether or not this revised process will also work well for analyzing other tasks that have heuristic elements. The data in this study indicate that much additional guidance is still needed for conducting a heuristic task analysis. It is our hope that this study will encourage others to conduct additional research to improve the available guidance for analyzing heuristic tasks.

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Table 1

Comparison of Various Knowledge Elicitation Techniques

Technique	Description	Advantage	Disadvantage
Observation	• involves familiar tasks, simulated familiar cases, limited information tasks, constrained processing tasks, and tough cases	• offers minimal interference with the expert's task and environment • helps identify problem-solving strategies that are not consciously accessible or to verify expert's description of what he or she actually does	• difficult to interpret the data • potential influence of the observer's presence on expert's behavior • expert's underlying reasoning is usually not revealed by their actions
Interview — **Structured**	• goal-oriented — follows a predetermined format	• provides more systematic and thus more complete coverage of the domain • improves efficiency and effectiveness of knowledge acquisition • can be applied to knowledge acquisition from multiple experts	• requires more preparation time and domain knowledge on the part of the elicitor who determines the interview format
Interview — **Un-structured**	• free-form interviews in which neither the content nor the sequencing of the interview topics is predetermined	• is able to elicit unanticipated knowledge • is best-suited for early knowledge elicitation sessions, for getting a broad view of the domain, or for establishing rapport with an expert	• requires facilitating skills for the interviewer • experts tend to provide a reconstructed version of reasoning and omit some components that may be important to solving the problem because they assume them to be obvious
Protocol Analysis	• thinking aloud • protocol must be analyzed based on a systematic breakdown of the information to produce a structured model	• no time delay between the expert's task performance and the report of the performance • creates a detailed picture of the representation	• is most time-consuming in terms of data analysis • subjective nature of data interpretation • gaps and jumps in verbalization
Content Analysis	• a way of organizing a mass of open-ended material by objectively and systematically identifying specific characteristics • seeks regularities while doing hypothesis testing		• is difficult to determine the appropriate categories
Discourse Analysis	• a way of parsing an interaction between the		

	elicitor and the expert		
Repertory Grids	• a multidimensional scaling method to elicit further conceptual knowledge about the domain	• is effective in very complex applications • is useful in finding patterns and structures • provides a conceptual framework for knowledge	• is restricted to analysis problems • is not likely to provide much information about the procedural knowledge
Critical Incident Method/ Critical Decision Method	• asks the experts to recall and retrospect about previously encountered cases and select cases on the basis of their importance guided by probe questions	• captures the kinds of knowledge and experience involved in real-world decision making and problem solving • combines multiple basic techniques such as protocol analysis, case-based reasoning, structured interview, and retrospection	• potential idiosyncracy • experts' self-structured recollections typically reveal what happened but offer little insight into why the judgments, assessments, and decisions that surrounded critical events
Case Study Analysis	• focuses on specific experiences, assuming that the remembering or enacting of a specific case will cue some information that may have been otherwise overlooked or forgotten • involves simulations in which the elicitor walks through the case with the expert step-by-step		• many of the cases involve very old memories, which increases the potential for memory retrieval errors and reconstructions on the part of the expert
Forward Scenario Simulation	• makes use of simulation to focus on a case		• the amount of knowledge required of the elicitor to describe the situation in explicit terms familiar to the expert

Table 2

Top-down Approach to Heuristic Task Analysis

Method	Task: Determine the media for a course
1. Identify the **goals** of the task (or subtask)	• the media will help the learner to master the objective, • the media will be cost effective, • the media fall within the constraints for the course development and implementation.
2. Identify the **considerations** for attaining each goal. (If there are lots of causal factors for a consideration, then it is helpful to also identify **subcategories** of considerations	For the third goal above: • budget, • skills of personnel available to teach the course, • availability of equipment for the course.
3. Identify specific **causal factors** for each consideration (or subcategory).	For the third consideration above: • numbers of equipment, • scheduling of equipment, • alternative uses of equipment, • features (capabilities) of equipment.
4. Analyze each causal factor to identify all **guidelines** an expert uses to perform this version of the task, that involve the causal factor.	For all the above factors: • If an insufficient number of the equipment is available for the projected number of students, do not select that delivery system. • If the equipment is not available at all the necessary times, do not select that delivery system. • If the equipment is available and would otherwise go unutilized, there is a stronger need for you to select that delivery system. • If the capabilities of the equipment do not meet the instructional needs, do not select that delivery system. Note: these examples are illustrative, not exhaustive, and there may be more than one guideline for a causal factor.
5. Identify any **decision rules** an expert uses to combine the guidelines into a performance model.	For you to do.
6. Identify specific **explanations** as to why each of the guidelines works, and combine the explanations into explanatory models.	For you to do.
7. Identify a **descriptive model** for any objects involved in performing the task.	There are no objects that one uses to select media for a course.

Table 3

Participant Profile for Study 1

	Expert #1	Expert #2	Expert #3
Status	Professor in Counseling Dept.	3rd Year Doctoral Student	1st Year Doctoral Student
Years of Experience	more than 20 years	5 years	3 years

Table 4

Strengths and Weakness of the HTA Process in Study 1

Strengths	**Weaknesses**	
	Problems	**Solutions**
• In-person interview seemed to work well for eliciting the experts' heuristic knowledge.	• Experts were not always able to verbalize their heuristic knowledge during theinterview.	➢ Incorporate various interview and observation techniques (e.g., simulated videotapes, staged cases).
• Working with multiple experts seemed to be beneficial.	• Simultaneously working with multiple experts was challenging in terms of checking and balancing.	➢ Offer strategies for working with multiple experts.
• In general, the HTA process seemed to be logical and sequenced appropriately to elicit experts' heuristic knowledge.	• Analyst's lack of task expertise was disadvantageous in questioning and prompting the expert.	➢ Acquire sufficient task expertise during the preparation.
	• It was difficult to use the top-down approach during the interview.	➢ Use bottom-up approach during interviews and categorize later.
	• Experts often got off-track or had difficulty in remembering details during the interview.	➢ Provide reference material during the interview.
	• There were many distractions when interviewing experts in their offices.	➢ Reserve a conference room and check out the interview conditions.

Table 5

Participant Profile for Study 2

	Expert #1	Expert #2
Status	MA student	Graduating BA student
Years of Experience	2 years as MA student	2 years as BA student
Evaluation	Passed evaluation during each term as a writing tutor	Passed evaluation during each term as a writing tutor

Table 6

Strengths and Weakness of the HTA Method in Study 2

Strengths	Weaknesses	
	Problems	Solutions
• Top-down process seemed effective • Interview process seemed effective • Researcher having sufficient domain knowledge was beneficial • Use of 5x8 cards during the interviews was effective • Having expert list decision points and choose one as the focus of the interview seemed effective	• Expert may need reassurance if he/she cannot respond to the questions designed to elicit heuristic knowledge. • Experts may have difficulty choosing a decision point to focus on. • Experts may have difficulty recalling or getting into the flow of the tutoring situation.	➢ At the beginning of the interview, reassure the expert that their task expertise may not be based on heuristic knowledge. ➢ Note when expert has difficulty and ask questions to facilitate recall of the case. ➢ Note when the expert has difficulty and ask questions to facilitate recall of the case.

Table 7

Strengths and Weakness of the HTA Method in Study 3

Strengths	Weaknesses	
	Problems	Solutions
• Expert was satisfied with speed of HTA process	• A lot of time was spent on identifying the simplest version.	➢ Minimize step 2, simplest version, if analysis not done for developing training curriculum
• HTA method was effective in eliciting tacit heuristics • Interview sheet as modified for this study helped guide analyst and speed up process	• A lot of time was spent on closely related tasks.	➢ In Step 1.3 clearly distinguish between main and related tasks, and keep distinction in mind throughout interview.
	• Certain words, e.g., *know, like*, gloss over or camouflage tacit knowledge.	➢ Analyst should be alert for such words and probe for heuristic knowledge.
	• HTA method reflects a single elicitation style.	➢ Analyst should be aware of various ways to work with experts to elicit knowledge.
	• HTA method reflects a single knowledge representation format.	➢ Expert may best portray heuristics with diagrams, tables, etc., in addition to using words.

Appendix A

Interview Questions

Questions related to the nature of task in general:

1. How do you perceive group counseling? Is it procedural, heuristic, or both?
2. If it's procedural, in what circumstances?
3. If it's heuristic, in what circumstances?
4. If it's both, in what circumstances?

Questions related to the simplest version of the task:

5. Could you think of any group counseling session, which is the simplest but still representative?
    - Tell me about the setting:
        - When did you lead the session?
        - How many participants did you have?
        - What kinds of people were they?
        - What was the goal of the session?
        - What are the main considerations to achieve the goal?
    - Tell me about major decisions you made during the session:
        - What was the procedure you follow (if there's any)?
        - What were the major decision-points at the session? (i.e., When did you intervene and how did you intervene?)
    - Tell me what made you to make such decisions:
        - What are the decision-rules at each decision-point?
        - What are the alternatives at each decision-point?
        - How does the decision rules work?
        - Could you explain why each of the rules worked or did not work?
        - How would you do differently if you encounter similar cases in the future?

Appendix B

Interview sheet for the Heuristic Task Analysis Method

Phase I - Prepare.

1. Prepare
   - Nice office...
   - The process we will be using...
   - Describe the task to me in general.
   - Describe the people who will be performing this task.
   - What are the main costs and constraints in terms of teaching people how to do this task?

Phase II - Identify the first learning episode.

2. Identify the simplest version of the task and simplifying conditions.
   - Recall the simplest case of you doing this task. Describe it very briefly.
   - What conditions distinguishes this version of the task from more complex versions?
   - Let's identify some major versions and any conditions that distinguish them.
   - Is this the simplest, most representative task?
     - How representative of the task is it? Does this example occur frequently? Is it going to be safe to do in training?
   - Is this a fairly complete list of the simplifying conditions?
3. Analyze the organizing content (mostly heuristics and descriptive theories)
   - Think of a **specific time** you performed this task (or videotape).
   - What are some key **decisions** you made?
   - What **knowledge** did you draw upon to make this decision? (What were you thinking when you made this decision?)
     - **Steps?** (procedural knowledge)
     - **Descriptive models?** (which describe the phenomena with which the SME works),
       - When you performed the task, what things were you dealing with?
       - Can you think of any sort of cause/effect relationships far those things, phenomena?
       - Multiple causes, multiple effects?
       - Chains of causes and effects?
       - What are the probabilities for these things happening?
     - **Guidelines?** (heuristic knowledge)
       - What are the **goals** for this instance of the task under the conditions we talked about?
       - What important **considerations** did you have in achieving the goal(s)? What are the main things you had to consider or pay attention to get achieve the goal(s).

- What are the **critical events** and **inputs** you have to do or think about to deal with each consideration?
- What sort of **guidelines** or **rules of thumb** would help someone handle this consideration?

- **Explanatory models?** (why the guidelines work)
  - Why do you think this guideline works?
  - Are any of the guidelines interrelated? What do you think are the reasons that these guidelines work?
  - What's the probability of each of the critical events happening?
- **Metacognitive/decision rules? (when** to use which steps, guidelines, and descriptive knowledge).
  - How did you decide when to use these guidelines/rules while you were working on this task?

- Recall a similar **example** of this task that constitutes the same type of version of the task. Go to beginning of Step 3.

4. Analyze the supporting content.
   - What additional information, understandings, skills, & affective qualities are required to do this version of the task?
   - Let's analyze this knowledge in terms of what people will have to learn to do the task.
5. Adjust episode size.
   - How much time should one class/learning session last?
   - Do you think this is the right amount of material for one session?
   - How much should we include?
6. Design the within-episode sequence.
   - Is this material in the order it will be used?
   - Have we left any prerequisites out or gotten them out of order?
   - Is there anything else they need to know before trying any parts of the task?
   - Does the material seem to be grouped together well?

Phase III - Identify the next learning episode.

7. Identify the next simplest version.
   - Let's rank the simplifying conditions we have in order of complexity.
   - What do you think might be the next simplest version of the task?
   - What do you think would be the best simplifying conditions for this version of the task?
8. Repeat steps 3-7 to identify all remaining versions of the task.

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Signature:	Printed Name/Position/Title: Ji-Yeon Lee, Assistant Professor	
Organization/Address: 145 Wardlaw Hall University of South Carolina Columbia, SC 29208	Telephone: 803-777-2907 E-mail Address: leejy@gwm.sc.edu	FAX: 803-777-7741 Date: 01/17/03

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